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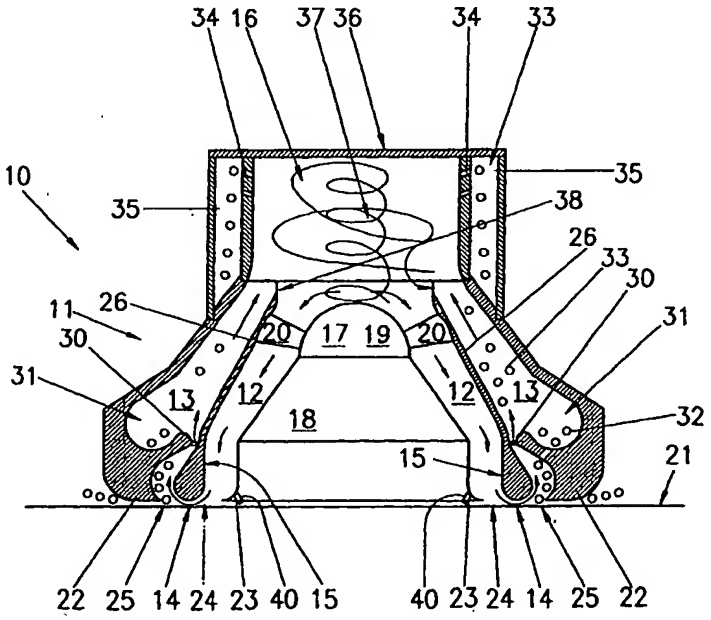

(57) Abstract

An apparatus (10) to separate a particle containing fluid such as dust laden air uses a Coanda blowing slot (14) to entrap particles into a recirculating fluid stream, and strips the particles out of the fluid stream in a separation chamber (31, 16) preferably using a vortex system. The apparatus can be a zero emission apparatus making it suitable in areas where conventional vacuum cleaners are inappropriate.

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AN APPARATUS FOR PICKING UP AND COLLECTING PARTICULATE MATERIAL

FIELD OF THE INVENTION

This invention relates to an apparatus to pick up and collect particulate material and in one form, the invention is directed to a vacuum cleaner such as a floor vacuum cleaner for use on carpets and the like. However, the invention need not be limited to vacuum cleaners, and can extend to devices to remove particles from a liquid, and other apparatus to remove particles from a gas, liquid or gas/liquid mixture. The invention can also extend to a separating system not necessarily limited to use with vacuum cleaners, and which uses a spinning motion to separate particles from a fluid flow. The invention will be described broadly with reference to vacuum cleaners, which can be domestic, industrial or specialised type cleaners.

BACKGROUND ART

Vacuum cleaners develop suction by means of a fan which discharges a powerful stream of air from the rear end of the casing. This sets up a powerful inflowing current of air which carries along any dust particles from the carpet or floor to which a suction nozzle is applied. The fan has a large number of blades set at an angle, the rotation setting up a flow of air in the axial direction. The air stream is passed through a bag in which the dust is precipitated and collected without appreciably obstructing the air flow.

One disadvantage with vacuum cleaners is that the entire volume of air passes into the dust collecting chamber and must pass through the walls of the dust bag. Should the dust bag become too full or clogged, this will reduce the efficiency of the vacuum cleaner and can result in damage to the vacuum cleaner itself.

The efficiency of a vacuum cleaner is dependent upon two factors being the air flow rate and the suction power. The suction performance is the product of two factors. Thus, when the flow rate is maximum, the suction is low and conversely when suction is high, the flow rate is low. For a vacuum cleaner to function efficiently, it is necessary for both the suction and the flow rate to be adequate.

Another disadvantage with conventional vacuum cleaners is that the air flow speed and volume is relatively low. The air flow speed along the carpet or ground and into the vacuum cleaner head largely determines the efficiency of the vacuum cleaner. Thus a high speed of air and a high volume of air would be desirable.

Other disadvantages of vacuum cleaners are the relatively high power consumption of the motor being typically over 1,000Kw making efficient vacuum cleaners difficult to be battery powered; and the low efficiency of the fan.

Our earlier patent application WO 97/08983 describes a vacuum cleaner having a curved body about which fluid can circulate, the curved body having a lower portion which in use is adapted to be adjacent the area to be vacuumed, the lower portion being dimensioned to provide a lower pressure surface, the curved body also having an upper portion dimensioned to provide a higher pressure surface, fluid acceleration means to accelerate the fluid about the curved body, a fluid stream splitter in the upper portion of the curved body to split the fluid into a recirculated portion which continues to move about the curved body, and a waste portion which passes into a dust collecting chamber and is exhausted therefrom.

The curved body may be in the form of a doughnut or toroid. The curved body need not be symmetrical and may be slightly elliptical in cross-section. The curved body need not be entirely curved, and portions of the curved body may be straight if desired. With this vacuum cleaner, the fluid stream splitter splits the fluid into a recirculating portion and a waste portion. The air passing into the waste portion needed to be exhausted through an upper exhaust duct which could be associated with a filter screen.

A possible disadvantage with this vacuum cleaner is that removal of the particulate matter from the waste stream was done by slowing the air down causing the particulate matter to drop down into a collection basket. For the finer particulate material, separation was not always very efficient. Also, a quantity of air still needed to be exhausted through the top of the vacuum cleaner.

It is known to separate particles from a fluid flow by causing the fluid to spin, and to remove the particles using centrifugal forces. Industrial cyclones use this principle. However known separators of this type are not very efficient, and especially if the separator needs to be quite small in size, and needs to separate quite fine particles. For this reason such separators have not found great commercial success in many applications such as vacuum cleaners.

Another disadvantage with almost all known vacuum cleaners and with spin type separators is that the cleaned gas or liquid stream is exhausted from the apparatus. This makes the apparatus unsuitable where exhaust emissions need to be minimised or even eliminated. For instance, persons with allergy problems find that any exhaust from a cleaning device can cause an allergic reaction. Hospitals and other clean rooms find that exhausts from a cleaning apparatus still spew contaminants into the air.

OBJECT OF THE INVENTION

The present invention is directed to an apparatus which can separate particles from a fluid flow.

In a specific form, the invention covers an apparatus to pick up and collect particulate material and which can be used as a vacuum cleaner and where the apparatus can separate the particulate matter with improved efficiency.

In a preferred form of the invention, the apparatus is a "zero emission apparatus" which means that there is little or no exhaust air passing from the apparatus. In this form, the apparatus finds particular applications in sterile environments and in environments where hazardous waste is required to be picked up and safely collected.

In another form, the invention is to a separating system which can be used with a vacuum cleaner or with other apparatus, and which utilises a particular spinning motion to separate particles from a fluid flow.

In one form, the invention resides in an apparatus to pick up and collect particulate material, the apparatus having a housing, a recirculating air stream or fluid stream passageway in the housing, the passageway having a

bottom slot, which can be annular and which is adapted to pass over the particulate material to be picked up, a curved body positioned in the slot and dividing the slot into two parts, the slot and the body being configured such that the air or fluid stream passes through one part of the slot, about a portion of the curved body and into the other part of the slot, and picking up the particulate matter in the process, a separating chamber communicating with or forming part of the passageway and in which the particulate material is separated from the air or fluid stream, and an acceleration means to accelerate the air or fluid stream through the passageway.

In another form, the invention resides in an apparatus for separating particles from a fluid stream, the apparatus comprising a chamber which has one or more outer walls, at least one fluid inlet adjacent an outer wall of the chamber, and at least one fluid outlet which is spaced inwardly from the fluid outlet, the construction and arrangement being that particulate containing fluid enters into the chamber through the at least one inlet and adopting a first larger diameter spinning motion, to spin particulate material towards the outer wall of the chamber, the fluid subsequently adopting a second smaller diameter spinning motion and passing back through the centre of the fluid having the first spinning motion.

In another form, the invention resides in a method of separating particulate material from a particle containing fluid stream comprising causing a first fluid stream to adopt a first larger diameter spinning motion to remove particles from the stream by centrifugal forces, and subsequently causing the fluid stream to adopt a second smaller diameter spinning motion and passing the fluid back through the centre of the first fluid stream.

In another form, the invention resides in a vacuum cleaner having a housing which has an internal recirculating air passageway through which an air stream recirculates, air accelerating means to accelerate the air stream through the passageway, the passageway having a first inner passageway and a second outer passageway, said passageways being joined at the bottom of the housing by an annular slot which is adjacent the area to be vacuumed, an annular curved body positioned in the slot and slightly inwardly

from the lowermost edge of the slot to divide the slot into an inner part which forms part of the inner passageway, and an outer part which forms part of the outer passageway, the body and slot being configured such that the accelerated air stream passes down the inner annular passageway, through the inner part of the slot, about the curved body and up into the outer part of the slot and into the outer passageway, and in the process picks up particulate matter from the said area, a separating chamber communicating with the outer passageway and in which the air stream adopts a spiral flow to spin out the particulate matter into a collection area, the inner passageway communicating with the separating chamber to allow the departiculated air stream to recirculate through the inner passageway and towards the slot.

The apparatus will be described with reference to its use as a vacuum cleaner but it should be appreciated that the term "vacuum cleaner" should be construed broadly and may include an apparatus which picks up particulate material other than from carpets and floors. For instance, the apparatus could be used to pick up and collect particulate materials in industrial and mining areas.

The separating chamber can separate the particulate material entrained in the air stream in an improved manner by having the air stream adopt a spiral flow in the separating chamber. In this manner, the particulate material can be spun out of the air stream using centrifugal force. This allows a better separation of particulate material from the air stream. The separating chamber can have a surround wall formed with openings through which the particulate material can pass together with a portion of the air stream. The surround wall can communicate with a collection area into which the separated particulate material can be collected. The collection area may include means to slow the speed of the air stream to cause the particulate material to separate therefrom.

In one form of the invention, the vacuum cleaner is configured such that little or no emissions emanate from the vacuum cleaner. This can be achieved by ensuring that as the air stream passes through the slot and about the curved body, no external air is sucked into the air stream from the

surrounding area. To prevent this, a proportion of the air stream can be split off prior to passing through the slot and this split off portion of the air stream can be directed to adjacent the slot such that the split off portion is entrained by the air stream passing through the slot. In this manner, little or no additional air is trapped by the air stream. Consequently, there is no net build up of air volume circulating through the apparatus and thus there is no need for an air outlet which can cause fine particles to be sprayed into the room.

Another advantage in splitting off a portion of the air is that this portion can be directed against the area to be cleaned at fairly high speed to assist in the dirt loosening and cleaning action.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will be described with reference to the following drawings in which

Figure 1 is a section view of a vacuum cleaner according to an embodiment of the invention.

Figure 2 is a bottom view of the vacuum cleaner of Figure 1.

Figure 3 is a section view of a vacuum cleaner according to another embodiment of the invention.

Figure 4A and 4B illustrate a corner attachment to the vacuum cleaner.

Figure 5 illustrates an apparatus for separating particles from a air stream according to another embodiment of the invention.

Figure 6 illustrates a variation to the apparatus of Figure 5.

Figure 7 illustrates a bottom view of a pick up head which is linear.

Figure 8 illustrates a side view of the pick up head of Figure 7.

Figure 9 is a bottom view of a pick up head which is annular.

Figure 10 illustrates a side view of the pick up head of Figure 9.

Figure 11 is a plan view of an apparatus for supplying air to the pick up head of Figure 9.

Figure 12 illustrates a section view of the apparatus of Figure 11.

Figure 13 illustrates the apparatus of Figure 11 connected to an

apparatus for separating particles which is a variation of the apparatus of Figure 5.2

BEST MODE

Referring initially to the section view in Figure 1, there is illustrated a vacuum cleaner 10 the major components of which are an outer housing 11, an internal recirculating air passageway which comprises an inner annular passageway 12, an outer annular passageway 13, an annular bottom slot 14, a curved body 15 positioned within the slot, an upper separating chamber 16, an air accelerating means in the form of a fan 17, and a motor 18 to drive fan 17.

Vacuum cleaner 10 can be formed from metal, plastic, composites or any other suitable material. The vacuum cleaner is fairly small and has a diameter of approximately 40cm and a height of approximately 40cm. Of course, larger or smaller vacuum cleaners are envisaged depending on the required use. The vacuum cleaner has a recirculating air passageway inside outer housing 11 and the arrows illustrated in Figure 1 show generally the direction of flow of the air stream. Fan 17 can be of a design described in International patent application PCT/AU93/00581. Fan 17 has a hub 19 and a number of extending blades 20. Fan 17 rotates at high speed causing air to be pushed at high speed down inner annular passageway 12 and towards slot 14. Slot 14 is between 5 to 20mm wide (although this can vary to suit) and is positioned at the bottom of the vacuum cleaner and adjacent the floor surface 21 which is to be vacuumed. The annular slot 14 is defined by a lower portion 22 of outer housing 11 and a lower portion 23 of the motor housing. Of course, portion 23 need not be part of the motor housing and can be formed separately. Positioned inside annular slot 14 is an annular curved body 15. The annular curved body 15 divides slot 14 into two sub-slots being an inner part 24 (a blowing slot) and an outer part 25. The lowermost curved portion of body 15 is spaced inwardly from the slot such that when the vacuum cleaner is placed on the floor 21, a small gap is provided between the bottom of curved body 15 and floor 21 which enables the air stream to pass around the curved body.

Curved body 15 has an upper annular portion 26 which extends

up and towards the bottom of separating chamber 16 and which functions to separate the inner annular passageway 12 from the outer annular passageway 13. The portion 26 is configured adjacent the fan blades 20 to allow the fan blades 20 to rotate within portion 26 with a fine contact between the outer edge of blades 20 and the inner wall of portion 26. Thus, this part of portion 26 functions as a shroud about fan 17.

As fan 17 is rotated at high speed, air passes through the fan and passes at high speed through inner part 24 which can be seen as an annular blowing slot. By virtue of the air being blown through the blowing slot, it adheres to curved body 15 and will follow the surface of the body by virtue of the Coanda effect. As air passes at high speed through the blowing slot and about the lowermost portion of curved body 15, it picks up particulate matter such as dust and dirt from floor 21 and carries the particulate matter around curved body 15 and up into outer annular passageway 13.

Outer annular passageway 13 tapers from a wider lower diameter adjacent slot 14 to a narrower upper diameter which communicates with the bottom of separating chamber 16. By virtue of this tapering, the air stream passing along outer annular passageway 13 is caused to spiral through the annular passageway at increased revs per minute. That is, as the particulate entrained air passes up passageway 13, it also spirals through annular passageway 13 at higher and higher revolutions per minute as it progresses towards separating chamber 16. The spiral action can be facilitated by providing a deflecting means 30 in passageway 13 the deflecting means being in the form of angled members such as slots, fins, or vanes which deflect the air stream into a spiral flow.

The lower portion of outer annular passageway 13 of this first embodiment is formed with a bulbous enlargement 31 which forms part of a first collection area. In this collection area, the larger entrained particles 32 separate from the upwardly moving air stream by virtue of their larger mass and fall into collection area 31 for later disposal.

Before enlargement 31, the outer passageway is narrowed to create a pressure drop in the outer passageway. The pressure drop causes the

air stream to attempt to increase speed. The deflecting means 30 assist in deflecting this air stream into a spiral flow so that it can increase speed.

The smaller particles 33 remain entrained in the upwardly moving and spiraling air stream. The air stream passes into the open bottom of separating chamber 16 and, at this point, the air stream is spiraling at relatively high speed and rpm. Once in separating chamber 16, the smaller particles 33 spin out of the air stream and pass through openings 34 in the surround wall of separating chamber 16. The smaller particles pass through the openings and into a second collection area 35. In this area, the speed of the air stream is slowed and this can be assisted by having baffles (not shown) in the collection area and the slowing of the air stream causes the smaller particles 33 to fall down and stay in the second collection area 35. The departiculated spiraling air stream reaches the top wall 36 of separating chamber 16 and spirals inwardly and downwardly towards the upper part of inner annular passageway 12. Reference number 37 references the downwardly spiraling air stream. Inner annular passageway 12 has an open top end 38 which communicates with the open bottom of separating chamber 16 but is spaced inwardly from outer annular passageway 13.

With this arrangement, air passing into separating chamber 16 through outer annular passageway 13 spins about chamber 16 and is forced to adopt a tight spiral 37 as it passes downwardly into the inner annular passageway 12 and through fan 17. As the air adopts the tighter spiral, it will spin at greater rpm and this will assist in spinning out fine particles which will then become entrained in the remaining air spinning upwardly (note: upwardly depends on one's viewing angle), within separating chamber 16. In this way, dust is kept from returning back through the fan or fluid drive. Only very fine particles pass back through the fan and do not impair its function to a great extent.

To assist in the cleaning action, and also to minimize entrapment of outside air, there are provided openings 40 immediately adjacent slot 14. Openings 40 can be in the form of an array of bores or can be in the form of an annular slot.

The air stream passing down inner annular passageway 12 will have a portion of the air split off and passed through openings 40 which has the effect of blowing high speed air onto the floor 21 to loosen the particulate material. Also, this split off portion of air will be entrained with the remaining air stream flowing about curved body 15 which means that there will be little or no additional air passing through the slot. Consequently, no vents are required in the collection areas to vent any build up of pressure caused by extra air being trapped in the fluid flow. If some air is trapped in the fluid flow, and vents are required, these vents can be made very small and can be covered by an extremely effective filter which is not possible with conventional vacuum cleaners where a high volume of air must be exhausted.

The fluid passing through bores 40 strikes the carpet, floor, or ground as jets. This loosens particular matter. That air then momentarily stagnates as its speed is substantially arrested. This raises its static pressure momentarily and it rushes towards the low pressure area created by the Coanda jet issuing from slot 24. The high speed jet from slot 24 wants to entrain, as does any jet. In this case, it entrains the fluid from bores 40 instead of any substantial amount of air from outside the device.

Figure 3 illustrates a second embodiment of the invention. In this embodiment, the fan 50 is spaced away from the annular slot 51. Otherwise, the invention works in a similar manner. For instance, with the vacuum cleaner illustrated in Figure 3, fan 50 accelerates an air stream through an inner tubular passageway 52 and towards the annular slot 51. Annular slot 51 is formed by virtue of a tapered cone insert 53 and the wall of outer annular passageway 54. An annular curved body 55 is positioned in slot 51 and again spaced slightly inwardly such that air can blow through a blowing slot 56 about curved body 55 and into outer passageway 54.

Bores 40, as described in Figure 1 can also be placed adjacent slot 56 of Figure 3 but are not illustrated. An underside view of the pick-up head of Figure 3 would look substantially like the view of Figure 2 with bores 40.

The section cut lines 57 illustrate that the annular slot 51 can be

spaced at any convenient distance away from fan 50. Outer passageway 54 again has a first annular collection area 62 to collect the heavier particles, and a separating chamber 58 which spins out the finer particles in a manner similar to that described with reference to Figure 1. Prior to collection area 62, the passageway is narrowed to create a pressure drop which causes the air stream to speed up. Deflectors can be used to assist in causing the air to spin as it moves along the passageway.

Separating chamber 58 again has openings 59 in the side wall through which the particles can pass and into a second collection chamber 60. In use, air flows through fan 50 where it is accelerated and pushed at high speed through annular blowing slot 56, about curved body 55, up into outer passageway 54, through passageway 54 and into the first collection zone 62 where the heavier particles leave the air stream. The air stream continues to pass through passageway 54 and into separating chamber 58 and in the process passageway 54 tapers inwardly which causes an increase in the rpm of the air stream. The air stream spins within separating chamber 58 and when it reaches outer wall 61, the air spirals in a tighter circle back into the inlet of inner passageway 52 and through fan 50.

Figures 4A and 4B illustrate a corner attachment for the vacuum cleaner. Corner attachment 80 is roughly triangular in shape when viewed in plan (see Figure 4B), and has two straight outer edges 81,82 and a curved inner edge 82A which compliments the outer curve of the vacuum cleaner wall. A pair of air flow tubes 83A,83B, extend through bores 95,96, and the tubes have one end 84,85 projecting into inner passageway 12 the ends being scooped to assist in the passing of a portion of the air stream through the tubes. The other end 86,87 of the tubes have a lower opening 88,89 which is sealed off when the attachment is in the position of Figures 4A and 4B. (Of course, the number and size of the tubes may vary.) The attachment is spring biassed by spring 90 which allows the attachment to be pushed against the outer wall of the vacuum cleaner. When this occurs, tubes 83A,83B, are pushed further into bores 95,96 and the tube openings 88,89 now communicate with a bore 91 which itself communicates with a chamber 92

which has an array of lower orifices 93.

When attachment 80 is pushed against the vacuum cleaner against the bias of spring 90, high pressure air can pass along tubes 83,84, through bore 91, into chamber 92 and through the orifices 93, and against the ground to collect dust and dirt particles. The dirt passes into a return tube 97 which slides within a bore 98. Return tube 97 communicates with outer passageway 13 but only when the attachment 80 is pushed up against the vacuum cleaner.

It should be noted that the pick-up head need not be annular in plan view, but can be any convenient shape in plan view.

The vacuum cleaner has a number of advantages. By having low or no emissions, the vacuum cleaner finds application in sterile environment such as hospitals. The vacuum cleaner can be used to pick up and collect hazardous particles with a reduced or no likelihood of any particles being vented from the vacuum cleaner. The motor 18 can be cooled by vents (not shown) passing through the vacuum cleaner but air passing through the vents does not mix with any of the recirculating air. After the air stream passes about curved body 15 of Figure 1, the air stream passageway increases in cross-section to slow the rpm of the air to facilitate removal of the larger particles 32. The passageway then tapers to narrow the cross-section and thereby to increase the rpm of the air.

It should be noted that liquids may be suctioned up by this vacuum cleaner and collected in the same way as particulate material and do not impair the system as long as the motor is isolated from them.

The fundamental features of this vacuum cleaner while not limiting it to a vacuum cleaner used only in the home as already aforementioned are: that either a minute amount or zero air or any other fluid is ejected. Some versions can function immersed in any liquid such as water to remove particulate matter from that fluid. That fluid re-circulates substantially within the system and there is no need to draw ambient fluid from the surroundings. Therefore no or little fluid is ejected from the system and is described as a substantially closed circuit system.

Particulate laden water or any liquid can be processed by certain versions of this device. Whether the Coanda pick-up head is placed at a distance from the motor and fan or other fluid acceleration means or very close by, that enables this closed circuit to function, and the majority of the dirt or other particulate matter can be removed by any means but preferably by a vortex as mentioned in this description. There is no need to remove every last piece of particulate matter during the first circuit, as it recirculates and does not then communicate back to the surroundings.

A version of the invention may be immersed in swimming pools to collect and separate particulate material from the water.

Figure 5 illustrates a vacuum-type cleaner according to a further embodiment of the invention. In this further embodiment, the lower part of the vacuum cleaner is similar to that described with reference to Figure 1 and therefore like numbers have been used to designate like parts. For instance, the vacuum-type cleaner in Figure 5 again describes an outer housing 11, an internal recirculating air passageway which comprises an inner annular passageway 12, and an outer annular passageway 13, an annular bottom slot 14 and an annular curved body 15 positioned within the slot. A fan 17 driven by a motor 18 is provided inside the housing. The annular curved body 15 divides the slot 14 into two sub-slots being an inner blowing slot 24 and an outer slot 25. Fluid such as air is accelerated by fan 17 to flow downwardly through inner slot 12, around curved body 15, and upwardly through outer slot 13. Above fan 17 is a vortex chamber 110 which is U-shaped in configuration. Air containing dust or other particular material passes up through passageway 13 and is adopting a spiral motion for the reasons described with reference to Figure 1. Air passes into vortex chamber 110 via an inlet 111 which is adjacent the wall of the vortex chamber 110. The air forms a vortex 112 in vortex chamber 110 and is in the form of a larger diameter vortex which is adjacent the walls of vortex chamber 110. The vortex follows the curved pathway of vortex chamber 110 and into a collection area 113. The vortex then adopts a second smaller diameter vortex 114 (also called the inner vortex) which runs back up the approximate middle of the outer vortex 112 to return back through

fan 17. Gravity helps to keep the dirt and particulate matter at the bottom of collection area 113. Collection area 113 can be in the form of a removable chamber or cup which can be fastened via a collar 115 which is disengagable so that collection area 113 can be removed and emptied. Collar 115 can be attached by any convenient method such as by being threaded or having engagable bayonets for securing the two portions together.

In order to have larger particles end up in collection area 113, the bulbous enlargement 31 has a smaller cross-section than the enlargement in Figure 1. This promotes sweeping of the larger heavier particles up through passageway 13 along vortex chamber 110 and into collection area 113. Thus, by having the vortex more intense, this can be achieved more readily. In the embodiment illustrated in Figures 5 and 6, passageway 13 does not need to slope inwardly but may, at any point, and especially at the entry into the upper part of vortex chamber 110, be sloping outwardly or any other configuration to assist with the upward travel of heavy particles spiraling with the vortex.

Vortex chamber 110 need not be exactly U-shaped or curved around 180°. For instance, it may be curved to a lesser or greater angle for whatever convenient, geometric and practical considerations. Any configuration can be achieved as long as the two vortices are formed being the outer vortex, and the inner vortex which travels in the opposite direction to the outer vortex.

Referring to Figure 6, there is illustrated an apparatus similar to that described with reference to Figure 5 but including a tube 116. The tube is positioned such that one end is substantially in the middle of the vortex chamber while the other end is in the collection area 113 and adjacent the end wall of the vortex chamber (the vortex chamber being considered to extend all the way to the bottom of collection area 113. The pressure in the middle of a vortex is slightly lower than the pressure near the periphery of the vortex. In Figure 6, a dirt collection bag 117, for instance a thin translucent bag, is placed in collection area 113. Tube 116 creates a lower pressure immediately inside the wall of collection area 113. In this way, although the pressure within the whole system is lower than atmospheric, tube 116 causes the bag to be sucked

against the walls of collection area 113 by virtue of the lower pressure. Tube 116 may be unnecessary as there can be found low pressure areas adjacent inner walls where fluid speed is highest. This keeps the bag open such that the vortex can rotate within the bag. Collection area 113 can then be decoupled and the bag removed for disposal or cleaning.

The plastic or other type of bag 117 can be frictionally restrained, say by an o-ring or other like device inside collar 115, and the weight of the dirt causes the rest of the bag inside the chamber, whose walls are represented by 119, to cling especially at the bottom where there may be trenches of any configuration or ribs, then the top of the bag adjacent collar 115 remains relatively stationery while the rest of the lower portion of the bag rotates with the rotatably disengagable collection area.

In this way, an upper portion of the bag plastic or otherwise, is rotated substantially as many times as it requires to rotate and disengage the collection area 113 and so the neck of the dirt collection bag is twisted to enclose the dirt found in the lower part of the bag. In this way, upon complete disengagement of the collection bag can be lifted out of the collection area and tied off to completely seal the dirt from the atmosphere. If the dirt collection bag is biodegradable material, it can then be dumped in a landfill or incinerated.

A further improvement of the invention may be where the air pathway through tube 116, upon rotational disengagement of the collection area, is also disengaged and upon further rotation a hole or passageway through to atmospheric air is opened. In this case, if the vacuum cleaner is allowed to run during disengagement, there will be quite a significant pressure difference between the outside of the bag found within the area 113 and the inside of that dirt collection bag. In this way, the bag will collapse onto the enclosed dirt, compressing it and then upon further disengaging rotation the dirt inside the dirt collection bag will be found in a much more compact form and the same tying off of the upper portion of the removable bag can occur as already described.

Returning to Figure 3, it should be noted that the version depicted in Figure 3 may also possess these latest aforementioned features and that the

collection chamber 62 is eliminated as are the slots 59 and the outside wall of the vortex chamber 58 can be extended to any distance and in any direction. It need not curve around the 180° but may curve around 90° or some other angle to allow it to function in this latest mentioned identical manner, i.e. it may have a collar which is threaded or has bayonets and is rotatably disengagable and may contain a dirt collection bag and may have the assistance of gravity to keep the dirt at the bottom of the collection chamber.

It should also be noted that the embodiment depicted as Figure 3 may have the handle which is shown uppermost of the drawing removed and may be on the floor as a type of canister version of a vacuum cleaner. Passageways 52 and 54 may have flexible walls such as a flexible tube within a flexible tube. Bulbous area 62 may have a reduced cross-sectional area. Collection chamber 60 is eliminated as are slots 59 and because a vortex chamber 110 as in Figures 5 and 6 is facing in a downward direction, that vortex chamber need not have the aforementioned curvature to it. In fact it may remain straight as depicted and yet the same features may apply. In effect, the addition of a threaded or bayoneted collar for rotational disengagement of one section from the other and the addition of a dirt collecting bag placed within and all of the same features exhibited such as tube 116 of Figure 6.

A further embodiment of the invention is where the Coanda pick-up head is not round, annular or some other shape when viewed in plan view from underneath, but may be configured as Figure 7 and Figure 8.

Figures 7 and 8 illustrate a pick-up head having a row of nozzles 120 (or a slot) through which pass a portion of the fluid delivered from the fluid drive. A Coanda blowing slot 121 is provided through which passes another portion of the fluid. A curved Coanda surface is provided. These passageways may be reversed. 123 is the intake slot. 124 is the fluid delivery passageway. 125 is the passageway for return of the fluid to the vortex chamber and then to the fluid drive (not shown). 126 are side fences to isolate the process from the atmosphere at each end.

In Figures 7 and 8, the arrowed lines represent the airflow. The row of nozzles may be in a straight line or follow a curved path, as may the

Coanda blowing slot. The suction head when viewed in plan may be straight or curved.

It should be understood that the nozzles and Coanda slot shown as annular when viewed from beneath may be straight. That would provide a pick-up head that may be rectangular, square, elliptical or any shape as well as substantially circular when viewed from below. The nozzles may be aimed at any angle.

The perimeter of the pick-up head may possess bristles to help it to conform as it passes over irregular surfaces. Other flexible means of conforming to irregular surfaces may be employed.

In one embodiment of the invention, another type of collection chamber may lie substantially parallel to the vortex chamber and the passage through which the dirt is flung may be near the top of the vortex chamber and this passageway or hole may be any size.

A means of disconnecting the air to the nozzles may be employed when repositioning the pick-up head from the floor to ceiling and vice versa. This may be automatic or manually activated.

A further embodiment of the invention is where the sucking or inlet slot may be found more medially than the Coanda blowing slot or nozzles.

In that case, the nozzles, or alternatively to them a slot, may be placed close to the periphery of the pick-up head whether the pick-up head is round, rectangular or any shape when viewed from below.

The Coanda blowing slot may be placed inwardly relative to the nozzles and aiming the jet toward the centre when viewed from below. The nozzles may or may not be deleted.

In this last case, the medial sucking slot may be deleted and a simple substantially centrally located hole substituted to return the air or other fluid to the fluid drive or vortex chamber.

It should be appreciated that in this case the fluid path via a tube may pass through the wall of the passage leading the air to the nozzles or blowing slot.

Otherwise the removal of dirt is accomplished by the already

mentioned means.

Figure 9 illustrates an underside view of a pick up head 130 according to this further embodiment of the invention. Figure 10 illustrates a side view of the pick up head 130. The pick up head is annular in shape with a point 131 for going into the corner of a room. The pick up head 130 has a ring of nozzles 132 spaced about the periphery of the head 130. The Coanda slot 133 is located towards an outer edge of the head 130. The ring of nozzles 132 directs air down into the carpet to loosen dirt as previously described. The air is removed from the carpet surface through a central air inlet 134. The head 130 further includes three rounded spacers 135. These spacers have a smooth surface and allow the head to easily slide over a carpet surface and to otherwise raise it slightly above a smooth floor.

The flow of air about the pick up head is shown by arrows. (The flow of air through nozzles 132 is not shown).

The air supply to the pick up head 130 is provided by a fan 136 as illustrated in Figures 11 and 12. Figure 11 is a plan view of the fan 136 and Figure 12 is a cross sectional view. The fan 136 is mounted within a housing 137 having an air inlet 138 and an air outlet 139.

The air inlet 138 is connected by a rigid or flexible tube to the air inlet 134 of the head 130. The air outlet 139 is connected by flexible or rigid tube to the Coanda slot 133. Whether the connection is by a rigid or flexible tube depends on the type of vacuum cleaner. A flexible tube may be used for a fan which in use sits on the floor. A rigid tube may be used where the fan is mounted directly above the head 130.

It can be seen in Figure 11 that the air inlet 138 feeds the air substantially tangential to the inside wall to assist the air to assume the cyclonic or spiral flow as previously described with reference to Figure 1.

The air inlet 138 feeds an air passageway 140. It can be seen in Figure 12 that the air outlet passageway cuts through the passageway 140 fed by the air inlet 138. This enables the air pathways to cross over to enable the air inlet 134 of the pick up head 130 to be placed substantially centrally.

Figure 13 shows the fan 136 of Figure 12 in communication with

a vortex chamber 141. This vortex chamber operates in a similar manner to that already described with reference to Figures 5 and 6. However, the means by which the vortex chamber 141 is attached to the apparatus is different to that as described above. The vortex chamber 141 has a collecting bowl 142 and a dirt collecting bag (not shown) within it as previously described. A trapeze 143 is pivotally attached to the apparatus at a point above the bowl 142. The trapeze can swing away from the bowl to disengage the bowl and can swing towards the bowl to engage the bowl. When the bowl is engaged as shown in Figure 13, the bowl is held against a plate like member 143 and is held in place by upward pressure. It can be seen that in this case, there is no need to use the rotating action to engage the bowl 142 as previously described. It can also be seen that by swinging the trapeze away from the bowl 142, the bowl 142 can quickly drop away to be emptied.

The vortex chamber 142 has a small hole or passageway 144 which passes through the bottom of the bowl to the trapeze. The trapeze is hollow such that the passageway allows air flow to communicate between the bowl and the trapeze.

Air passageway 144 transmits the air pressure differential that causes the bag inside bowl 142 to remain inflated while the vortex rotates within that bag. In this way, the passageway 144 functions in a similar manner to tube 116 as described with reference to Figure 6.

As the trapeze is hollow, the air pressure differential is transmitted through the trapeze from where it pivots at its attachment points. In this way, an area of lower cross sectional area, and therefore lower pressure can communicate through the trapeze and back up the inside of the underside of the bowl. That air pressure may not be found immediately at the engagement points of the trapeze but a passageway may lead to these points from a more suitable lower pressure area within the system.

It can be seen that this arrangement represents a very quick and easy way of engagement and disengagement of the dirt collecting bowl 142 including the inflatable bag within it. Another feature of this improved bowl and attachment method is that by simple rotation of the bowl between an insert

hand, the dirt collecting bag may be rotatably sealed onto the dirt as already described above and disengaged easily for disposal.

This invention offers further advantages over other vacuum devices. It is potentially smaller, lighter and simpler than many other vacuum devices.

Also, the outside casing or shell may be simply held in position by its own internal low pressure enabling ease of emptying, cleaning internal surfaces or for quick access for repairs or maintenance.

There may be quite a number of geometric configurations of the invention without departing from the spirit and scope of the idea.

It should be appreciated that various other changes and modifications can be made to the embodiment described without departing from spirit and scope of the invention.

CLAIMS:

1. An apparatus to pick up and collect particulate material, the apparatus having a housing, a recirculating air stream passageway in the housing, the passageway having a bottom slot which is adapted to pass over the particulate material to be picked up, a curved body positioned in the slot and dividing the slot into two parts, the slot and the body being configured such that the air stream passes through one part of the slot, about a portion of the curved body and into the other part of the slot, and picking up the particulate matter in the process, a separating chamber communicating with or forming part of the passageway and in which the particulate material is separated from the air stream, and an acceleration means to accelerate the air stream through the passageway.

2. The apparatus of claim 1, wherein air passing into the separating chamber adopts a spiral flow to spin out the particulate matter into a collection area, prior to passing back towards the bottom slot.

3. The apparatus of claim 2, wherein the slot is annular.

4. The apparatus of claim 3 in the form of a vacuum cleaner having a housing which has an internal recirculating air passageway through which an air stream recirculates, air accelerating means to accelerate the air stream through the passageway, the passageway having a first inner passageway and a second outer passageway, said passageways being joined at the bottom of the housing by an annular slot which is adjacent the area to be vacuumed, an annular curved body positioned in the slot and slightly inwardly from the lowermost edge of the slot to divide the slot into an inner part which forms part of the inner passageway, and an outer part which forms part of the outer passageway, the body and slot being configured such that the accelerated air stream passes down the inner annular passageway, through the inner part of the slot, about the curved body and up into the outer part of the slot and into the outer passageway, and in the process picks up particulate matter from the said area, a separating chamber communicating with the outer passageway and in which the air stream adopts a spiral flow to spin out the particulate matter into a collection area, the inner passageway communicating with the

separating chamber to allow the departiculated air stream to recirculate through the inner passageway and towards the slot.

5. The apparatus of claim 4, wherein the separating chamber has a substantially inverted U-shape, and the collection area is at the lower end of one leg of the U-shaped chamber.

6. An apparatus to pick up and collect particulate material from a fluid stream containing particulate material, the apparatus having a housing, a recirculating fluid stream passageway in the housing, the passageway having a bottom slot which is adapted to contact the particulate containing fluid stream, a curved body positioned in the slot and dividing the slot into two parts, the slot and the body being configured such that the fluid stream passes through one part of the slot, about a portion of the curved body and into the other part of the slot, and picking up the particulate matter in the process, a separating chamber communicating with or forming part of the passageway and in which the particulate material is separated from the fluid stream, and an acceleration means to accelerate the fluid stream through the passageway.

7. An apparatus for separating particles from a fluid stream, the apparatus comprising a chamber which has one or more outer walls, at least one fluid inlet adjacent an outer wall of the chamber, and at least one fluid outlet which is spaced inwardly from the fluid outlet, the construction and arrangement being that particulate containing fluid enters into the chamber through the at least one inlet and adopting a first larger diameter spinning motion, to spin particulate material towards the outer wall of the chamber, the fluid subsequently adopting a second smaller diameter spinning motion and passing back through the centre of the fluid having the first spinning motion.

8. A method of separating particulate material from a particle containing fluid stream comprising causing a first fluid stream to adopt a first larger diameter spinning motion to remove particles from the stream by centrifugal forces, and subsequently causing the fluid stream to adopt a second smaller diameter spinning motion and passing the fluid back through the centre of the first fluid stream.

9. An apparatus to pick up and collect particulate material, the

apparatus having a passage, fluid acceleration means for accelerating fluid flow through the passage, a fluid inlet in communication with the passage and through which particle entrained fluid can pass into the apparatus, wherein the apparatus further includes a particle separation means which comprises a chamber which has one or more outer walls, at least one fluid inlet adjacent an outer wall of the chamber, and at least one fluid outlet which is spaced inwardly from the fluid outlet, the construction and arrangement being that particulate containing fluid enters into the chamber through the at least one inlet and adopting a first larger diameter spinning motion, to spin particulate material towards the outer wall of the chamber, the fluid subsequently adopting a second smaller diameter spinning motion and passing back through the centre of the fluid having the first spinning motion.

10. The apparatus of claim 9, which is in the form of a vacuum cleaner.

11. The apparatus of claim 10 having a housing and the chamber is removably attached to the housing.

12. The apparatus of claim 11, which includes a frame member for holding the chamber, the frame member being pivotably attached to the housing.

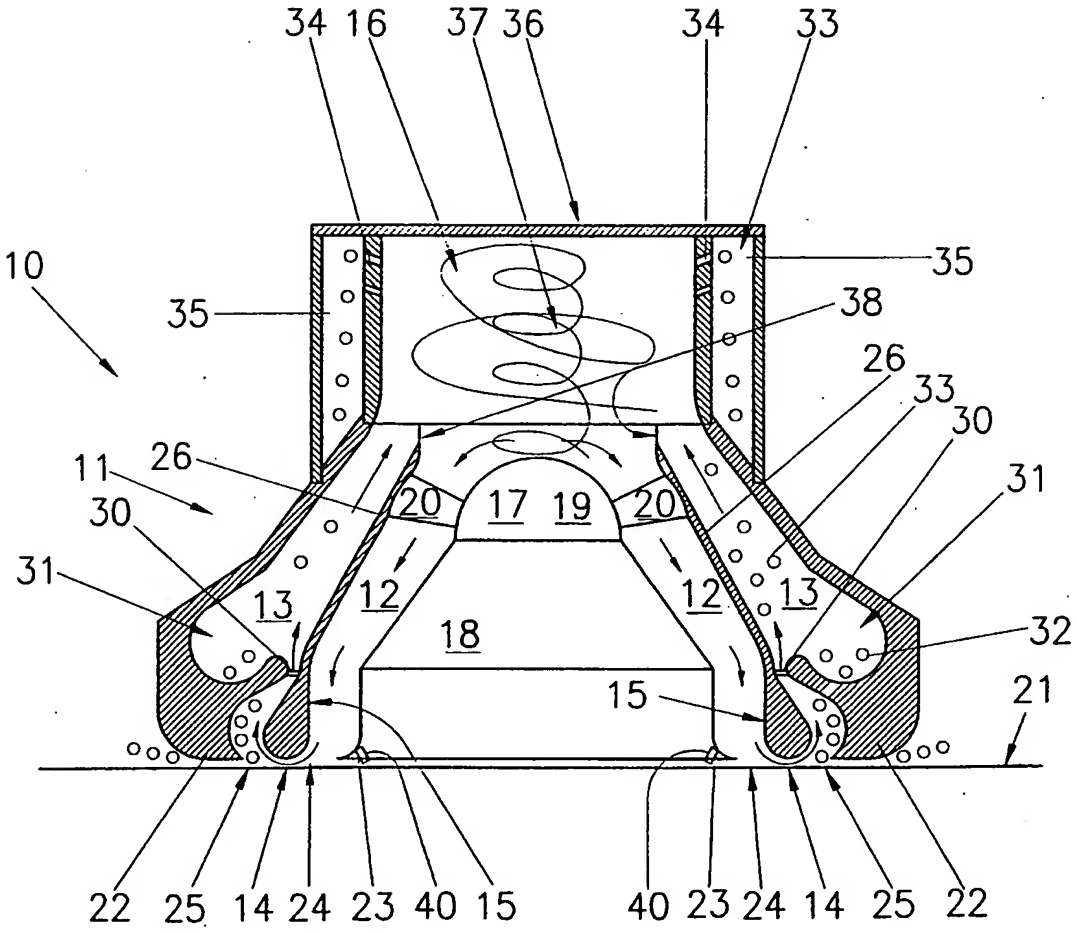
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FIG 1.

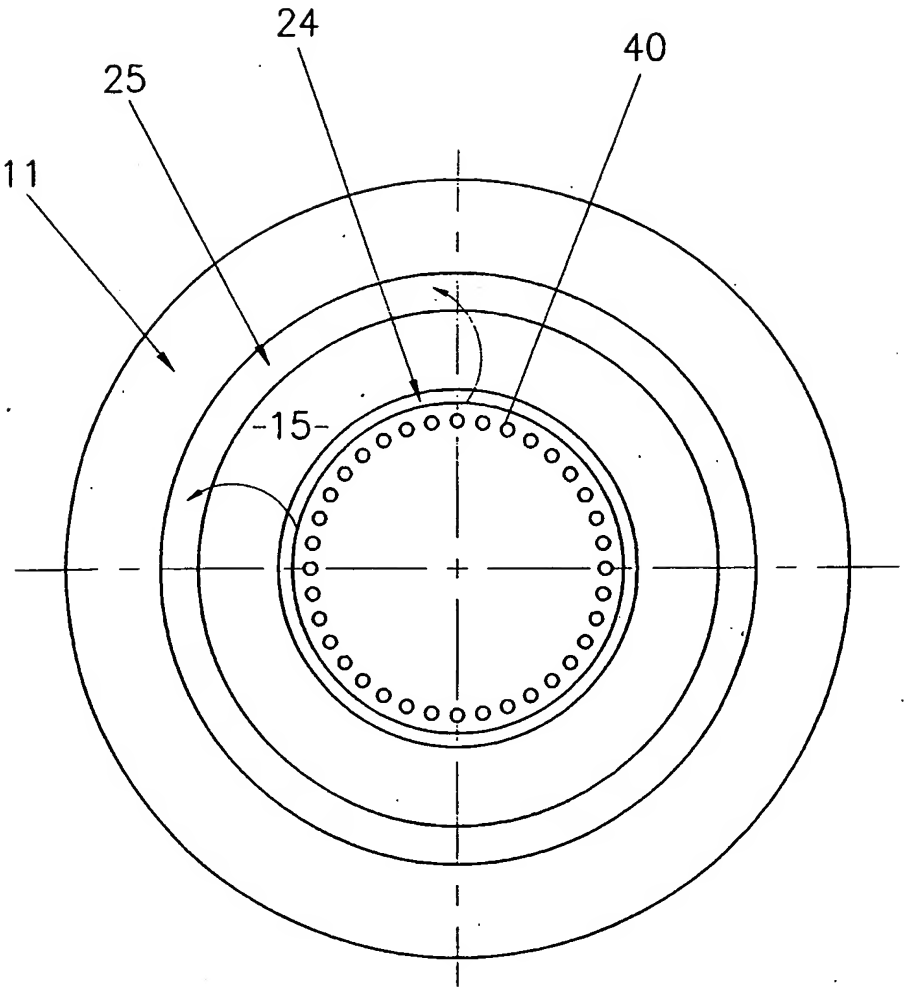

FIG 2.

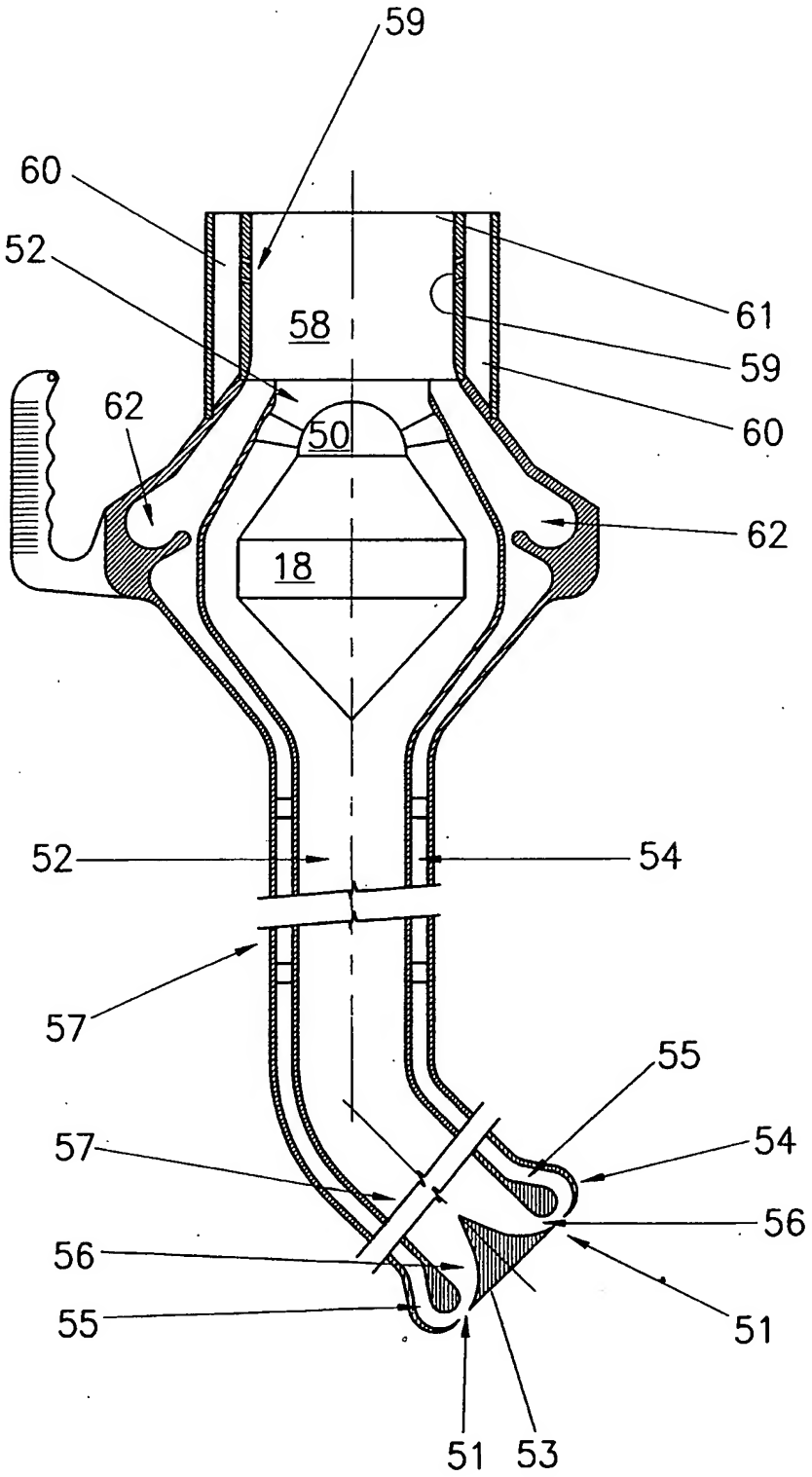

FIG 3.

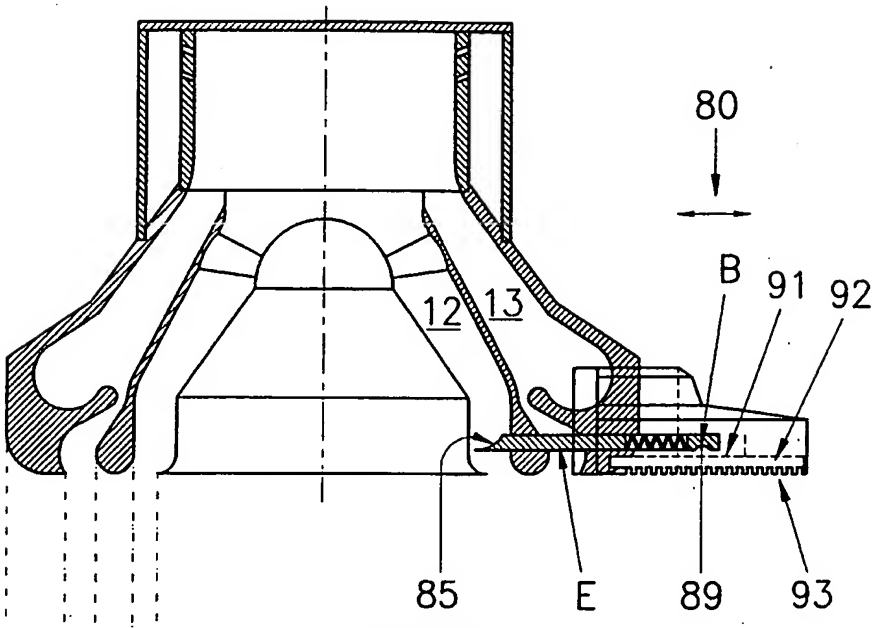
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FIG 4A.

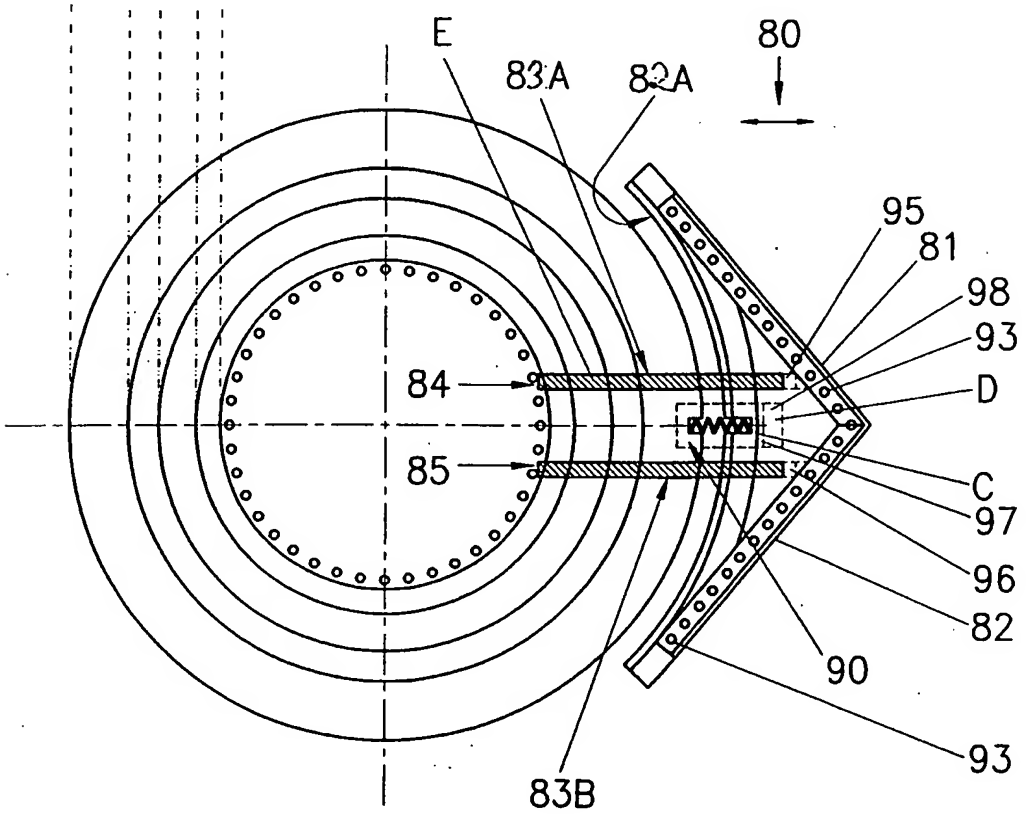
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FIG 4B.

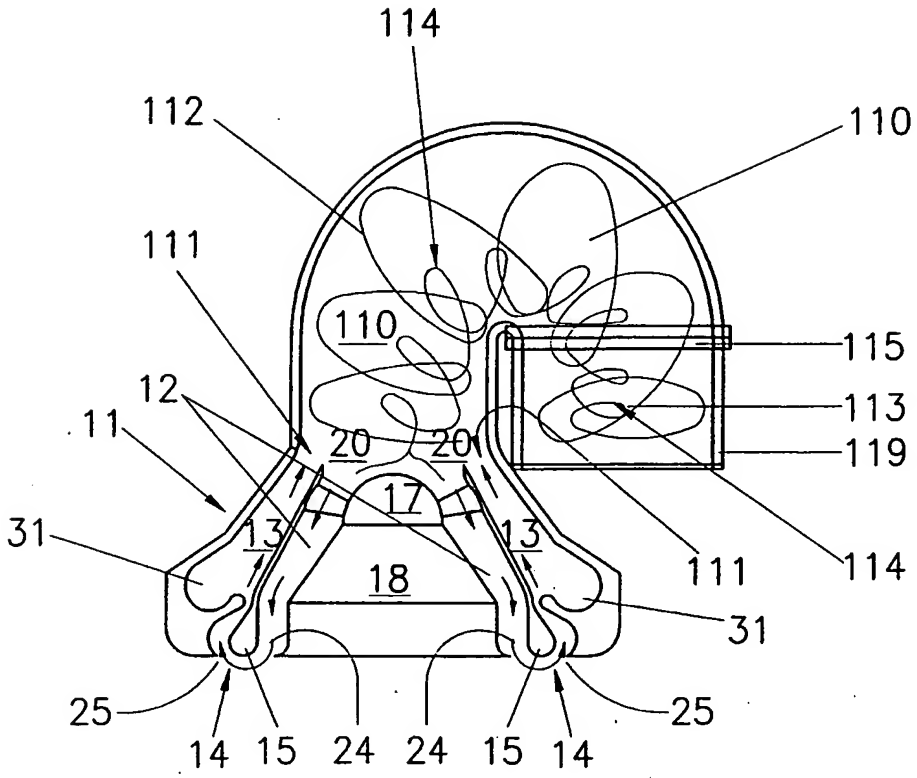
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FIG 5.

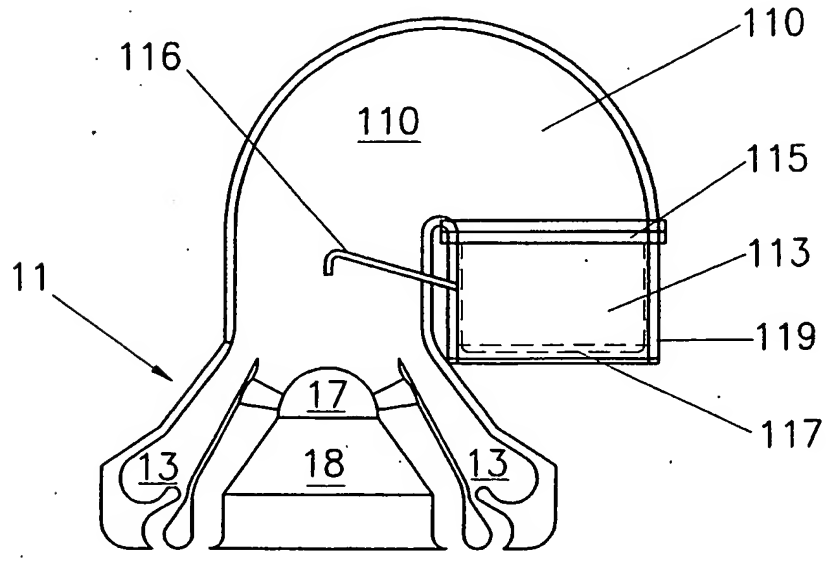
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FIG 6.

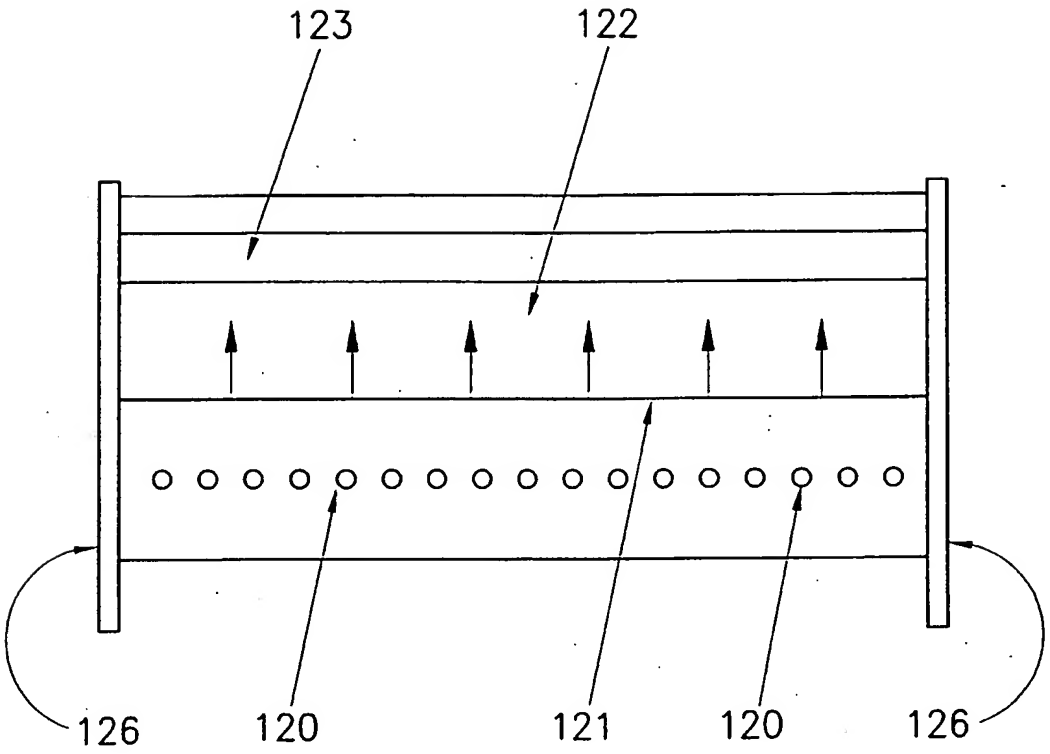

FIG 7.

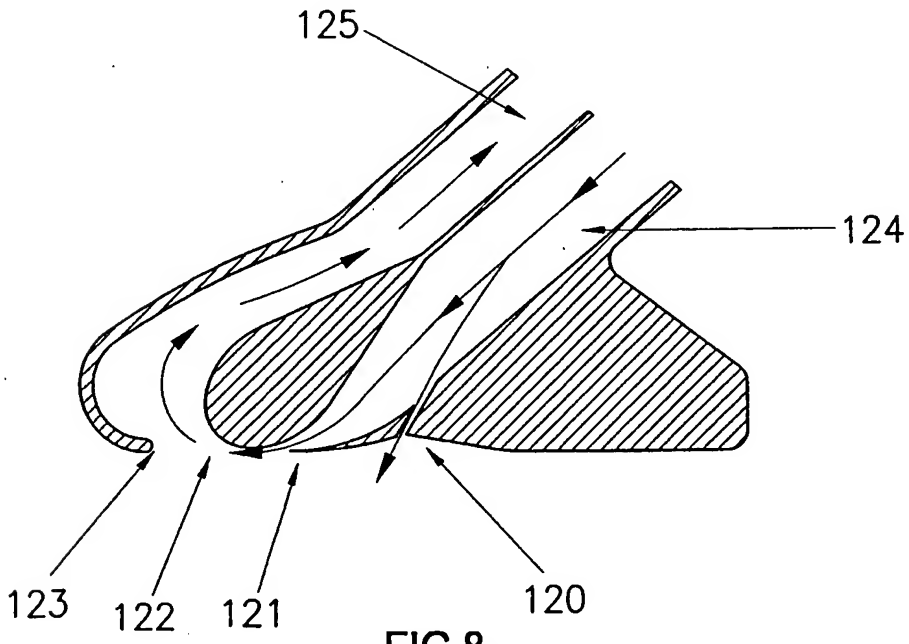

FIG 8.

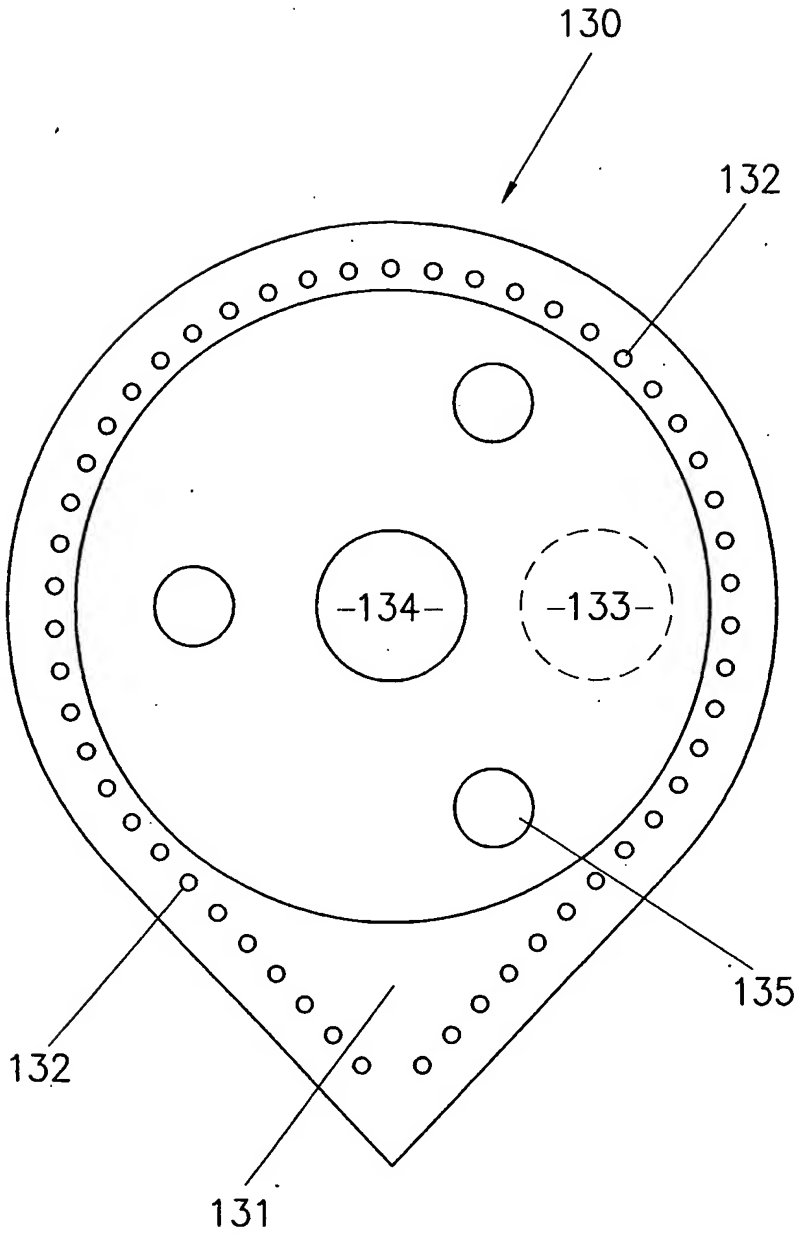

FIG 9.

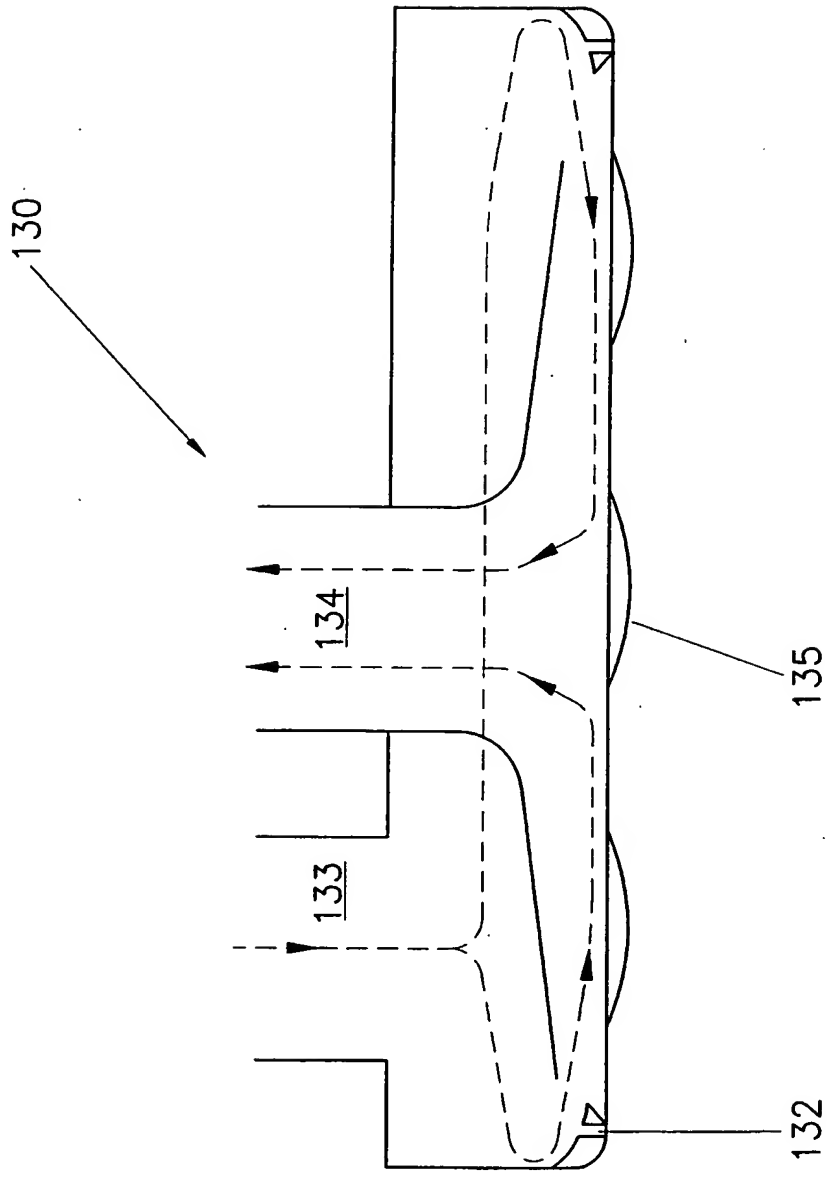

FIG 10.

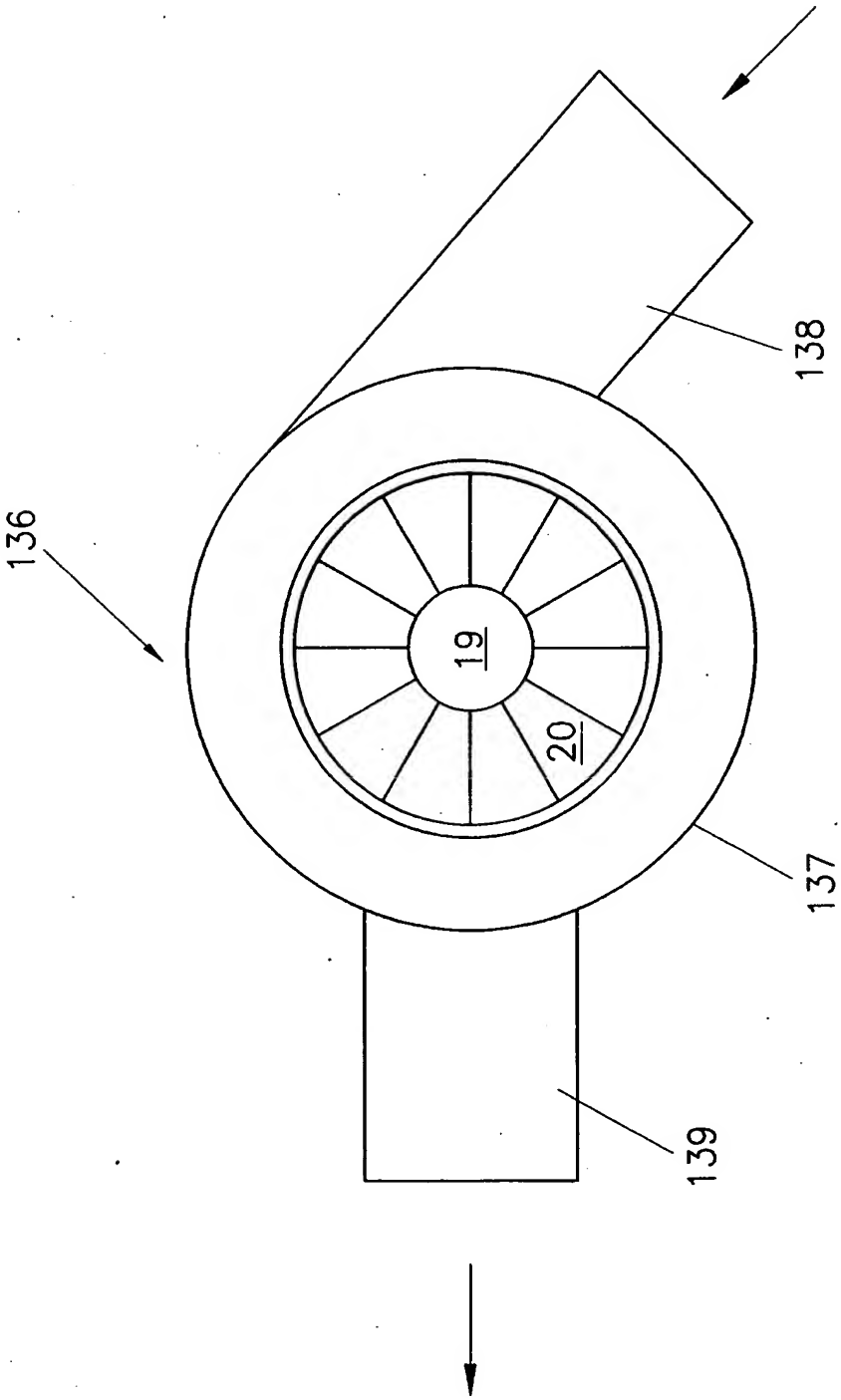

FIG 11.

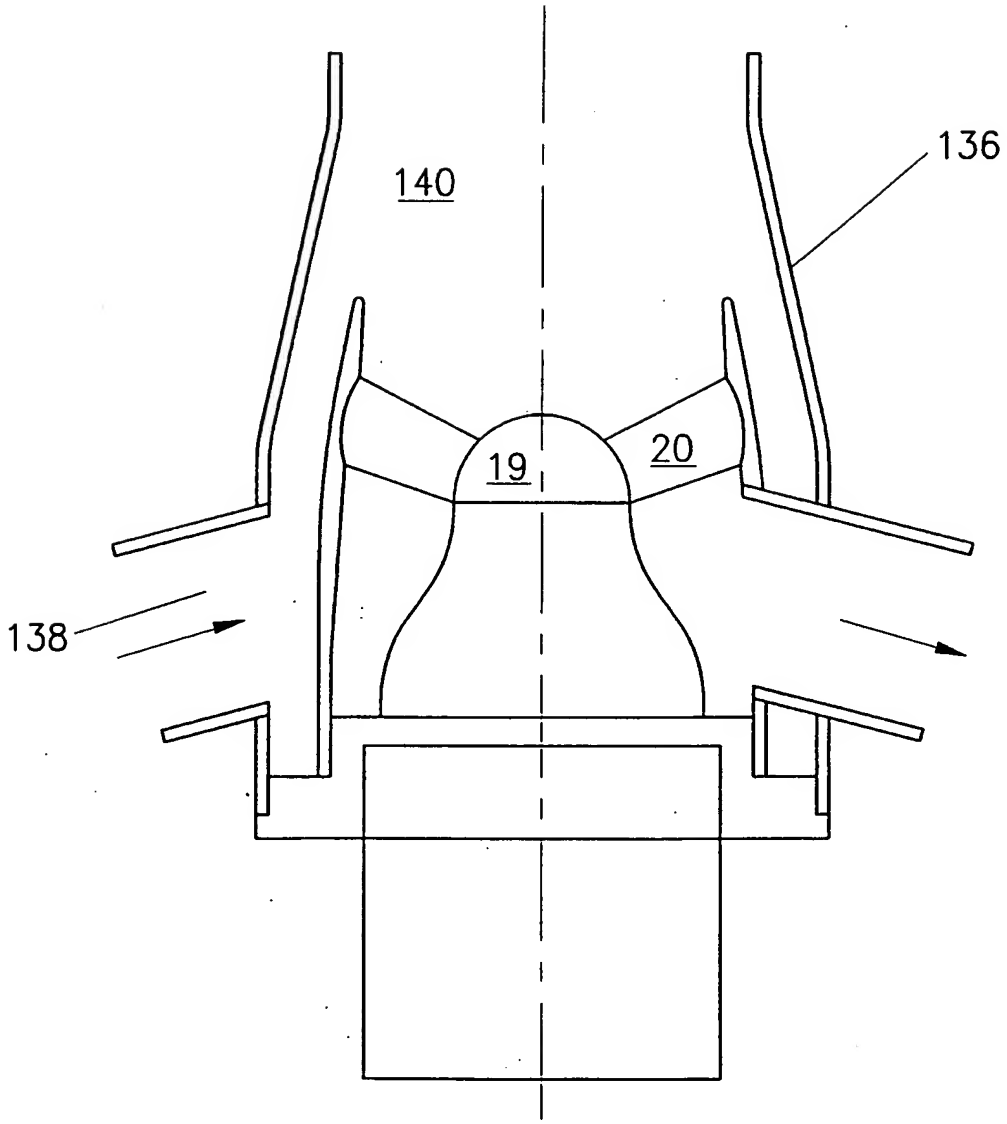

FIG 12.

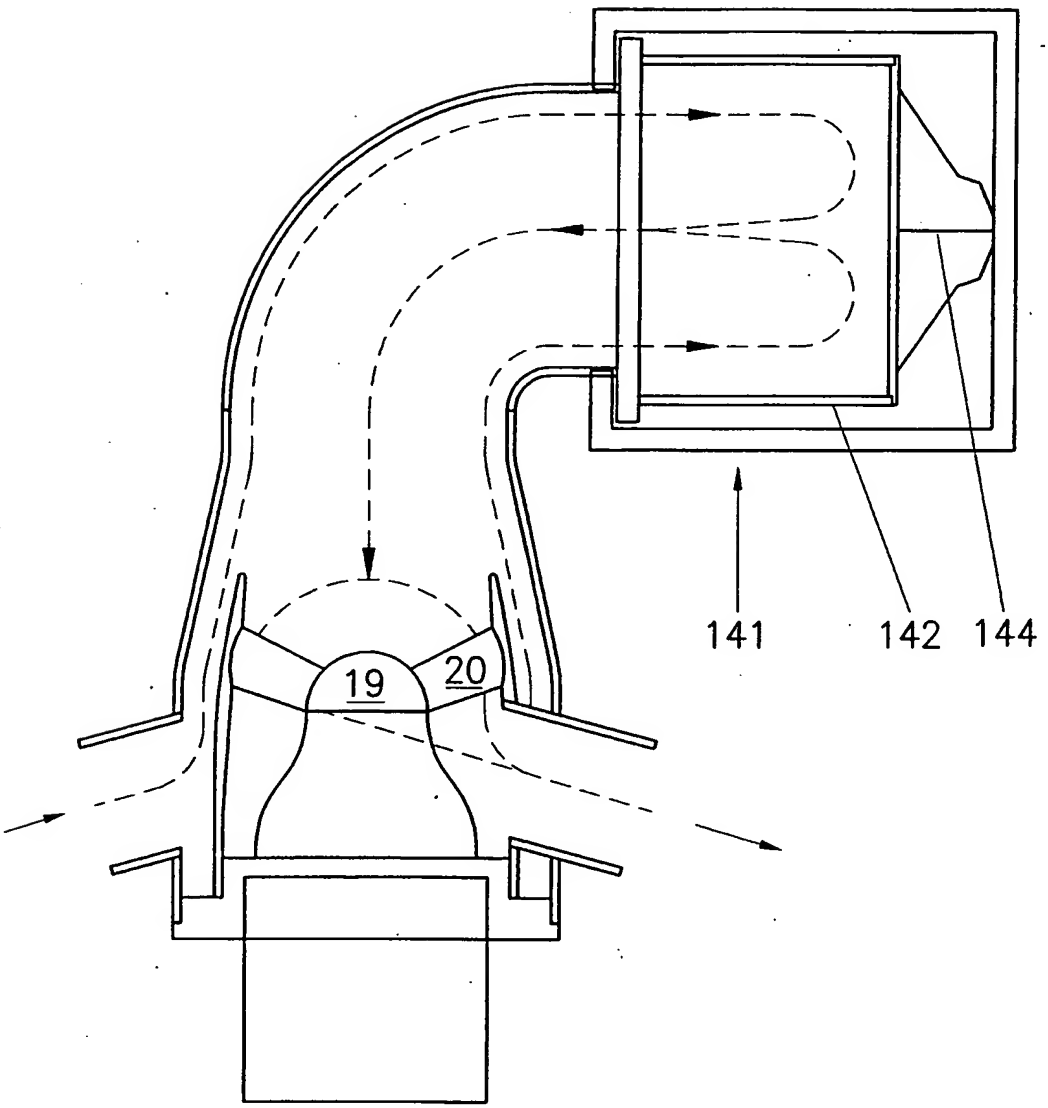

FIG 13.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00861

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: A47L 9/10, 9/16; B01D 45/16; B04C 5/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: AS ABOVE

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Derwent World Patent Index

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 042723 A (ROTORK APPLIANCES LIMITED) 30 December 1981 See figure 1	7-12
X	EP 728435 A (BLACK & DECKER INC) 28 August 1996 See figure 3	7-12
X	GB 2315231 A (NOTETRY LIMITED) 28 January 1998 See figures 1 and 2	7-12

☐ Further documents are listed in the continuation of Box C

☒ See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 December 1999	14 DEC 1999

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	**D.R. LUM** Telephone No.: (02) 6283 2544

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00861

Box 1 Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See attached sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00861

Box (continuation)

Lack of unity

The international application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept. In coming to this conclusion the International Searching Authority has found that there are different inventions as follows:

1. Claims 1-6 are directed to an apparatus to pick up and collect particulate material. It is considered that the curved body positioned in the slot and dividing the slot into two parts comprises a first "special technical feature".

2. Claims 7 & 8 are directed to an apparatus for separating particles from a fluid stream and claims 9-12 are directed to an apparatus to pick up and collect particulate material It is considered that causing the fluid to adopt a first larger diameter spinning motion and then a second smaller diameter spinning motion and passing the fluid back through the centre of the first fluid stream comprises a second "special technical feature".

These groups are not so linked as to form a single general inventive concept, that is, they do not have any common inventive features, which define a contribution over the prior art. The common concept linking together these groups of claims is a separating chamber in which the particles are separated from the fluid stream. However this concept is not novel in the light of the documents cited in this report. Therefore these claims lack unity a posteriori.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/AU 99/00861

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	42723	AT	14974	CA	1182613	DE	3171910
		DK	2721/81	JP	57066728	JP	61191329
		US	4593429	US	4826515	US	4853011
		US	5160356				
EP	728435	GB	9503334				
GB	2315231	AU	34503/97	CN	1230100	EP	918481
		WO	9802080				
END OF ANNEX							